

Nature and Origin of Hypervelocity Stars

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The exact shape of the Galactic dark matter halo is still under discussion. Calculating three dimensional kinematic scatterings, Gnedin et al. (2005, ApJ, 634, 344) showed that the spatial and velocity distribution of Hypervelocity Stars (HVSs) can provide significant constraints on the shape and density distribution of the Galactic dark matter halo. Knowing the properties of the dark matter halo is important in understanding the formation and evolution of galaxies and to unveil the nature of dark matter.

HVSs move so fast that they are unbound to the Galaxy. The first HVS was discovered in 2005 by the Harvard group (Brown et al. 2005, ApJ, 622, L33). HVS 2 and 3 were discovered shortly after this by the Bamberg group (Hirsch et al., 2005, ApJ, 444, 61, Edelmann et al., 2005, ApJ, 634, 181). At that time dynamical ejection from the massive black hole in the Galactic Centre (GC) was considered to be the only mechanism to accelerate stars beyond the escape velocity from the Galaxy. It is well established that the GC hosts a super-massive black hole (SMBH, Schödel et al. 2002, ApJ 596, 1051, Ghez et al. 2005, ApJ 620, 744) with a mass of almost 4 million M_{\odot} . Already in the late eighties, it was predicted from numerical experiments that a star can be ejected from the GC with velocities exceeding the escape velocity of the Galaxy by the disruption of a binary through tidal interaction with its central massive black hole (Hills, 1988, Nature 331, 687), while about 50% of the HVSs remain bound to the Galaxy (Brown et al., 2007, ApJ, 671, 1708).

This theory about a GC origin of HVS is still not proven by observations. In fact, in the case of J0136 the proper motion measurements exclude an origin in the GC (Tillich et al., 2009, A&A, 507, 37). Among other stars that challenge the SMBH paradigm (for example HD 271791, Przybilla et al. 2008, ApJ, 684, 103; HIP 60350, Irrgang et al. 2010, ApJ, 711, 138) HVS 3 seems to be the most problematic case: an origin in the GC would mean a travel time to its present position in the Galactic halo of about 100 Myr. This is in contrast to its main sequence lifetime of only 18 Myr. As HVS 3 is located much closer to the LMC than to the GC, an origin in this galaxy was suggested by Edelmann et al. (2005, ApJ, 634, 181). However HST proper motions argue for an origin in the GC, leading Brown et al. (2010, ApJ, 719, 23) to favour the GC as place of origin. This implies that the progenitor was a triple system and a hypervelocity binary was ejected that subsequently merged to form a blue straggler (Ginsburg and Perets, 2011, arXiv:1109.2284). Raghavan et al. (2010, ApJS, 190, 1) showed that the fraction of triples among OB stars is about 50% (most of the known HVSs are of late B spectral type). Therefore, the disruption of a triple system by the SMBH leading to the ejection of a binary star is very likely. No such hypervelocity binary has been discovered yet although it is more likely to find a close binary than an already merged blue straggler.

Most of the known HVSs were 'discovered' and 'classified' as HVS based on their radial velocity only, but to achieve the full 6D phase space information their proper motion and distances need to be known. These measurements can only lead to reliable results if an accurate distance of the star is known. However the major problem is that the evolutionary state of most HVS candidates is also still ambiguous – either they are far distant (intrinsically bright) massive main sequence stars (MS) with short lifetimes or closer (intrinsically faint) low mass blue horizontal branch stars (BHB), sufficiently long-lived to have travelled from the GC. This degeneracy occurs from the coincidence that the main sequence and horizontal branch overlap at the particular temperature of late B type stars of about 10000K, hence, we lack crucial information on their estimated distances which is the most important parameter for an analysis of their kinematics. For HVS 1 Fuentes et al. (2006, ApJ, 636, 37) were able to show with high-precision photometry a low-amplitude, slow variability of the star which indicates that the star is a MS star, since BHB stars do not appear to be variable.

We propose to measure light curves of 4 known HVSs and 11 new HVS candidates observable in K2 campaign 1. For latter we obtained atmospheric parameters (T_{eff} , $\log g$) from SDSS-magnitudes and estimated distances assuming that they are MS stars, which allowed us to predict proper motions that the stars must have if they originate from the GC. All of them are late B type stars and their Galactic restframe velocity is predicted to be of the order or higher than the local escape velocity. Due to the degeneracy in the region of late B type stars the available information is insufficient to distinguish a BHB star from a MS star. Therefore we propose to measure lightcurves for our sample in order to search for pulsations which indicate a MS star (as for HVS 1, Fuentes et al. 2006, ApJ, 636, 37). This will allow us to determine the stars' true nature. Together with proper motion measurements it will be possible to determine their origin and to unravel whether the stars are bound to the Galaxy or not. In addition the K2 mission allows us to search for close companions via eclipses, reflection effects from a cool companion or ellipsoidal deformations of the primary caused by a white dwarf companion predicted by models of the triple ejection scenario.

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